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METHOD AND DEVICE FOR CONTINUOUSLY COATING A METAL STRIP WITH A POLYMER COMPOSITION

BACKGROUND OF THE INVENTION

The invention relates to a method and a device for continuously coating a metal strip with a polymer composition.

A metal strip has two faces: the face to be coated is referred to hereinafter as the "external face" and the opposite face is referred to hereinafter as the "internal face".

A conventional coating device shown in Figure 1 includes:

- polymer composition application means, including a support roller 1 and means 3 for applying a layer of the composition to the external face Be of the strip, and
- means for feeding the strip continuously over the support roller 1 with its internal face Bi in contact with the surface of the roller.

The means for applying the polymer layer can extrude the polymer layer directly onto the strip, for example; the extrusion means then also form the layer; if this kind of application means is used, the polymer composition is free of solvent and the polymer is applied in the molten state.

The means for applying the polymer layer in the molten state can take the form of a device which includes two rollers bearing on each other and between which the strip to be coated is fed, as shown in Figures 2 and 3; in addition to the support roller 1 there is an applicator roller 2; during application, the external face Be of the strip and the coating come into the contact with the applicator roller 2.

As shown in Figure 2, the application means with two rollers 1 and 2 bearing on each other indirectly can be used to apply the polymer by a rolling process: the two rollers then revolve in opposite directions and the polymer composition P to be applied is introduced between the strip B and the applicator roller 2.

As shown in Figure 3, the above application means can also be used when a polymer layer N is formed on the applicator roller 2, for example with the aid of the means 3, and is then transferred from the applicator roller 2 to the strip B; the two rollers can then revolve in the same direction, as shown in Figure 3.

If a rolling process is used (Figure 2), the applicator roller 2 generally has a hard and non-deformable surface; the rollers are metal rollers, for example; this limits the risk of the polymer composition sticking to the rollers.

During and after application the polymer composition comes into direct contact only with the applicator roller, and this is therefore the only roller subject to the risk of sticking problems occurring: the risk is limited by choosing a hard surface and the hard surface is preferably cooled.

Before the polymer composition layer is applied to the strip to be coated, the strip is often pre-heated, in particular to improve the adhesion of the layer to the metal; this is particularly useful in the case of polymer compositions based on polyolefins, which are nonpolar and therefore adhere less readily to polar materials such as metals.

For the preheating step, if the support roller is provided with heating means, all that is required is to feed the strip over the heated support roller before applying the polymer layer, with the internal face of the strip held in contact with the hot surface of the roller: feeding the strip over the roller therefore pre-heats it to the temperature of the roller, during the duration of the feeding over this roller.

To limit the risk of sticking (see above), when the application means include a support roller 1 and an applicator roller 2 bearing indirectly on the support roller as previously described (Figure 2), the support roller 1 generally has a deformable surface, for example

a rubber surface, and the applicator roller 2 generally has a non-deformable surface, for example a metal surface.

When applying thermoplastics polymer compositions, it is sometimes necessary to obtain coatings with an amorphous or weakly crystalline structure; it is then important to carry out a quenching (fast cooling) operation after applying the layer to the strip; to be effective this quenching must be carried out as quickly as possible after application.

Referring to Figure 4, to be able to use the above-described device (the device shown in Figure 2, for example), and including a support roller with a deformable surface and an applicator roller with a non-deformable surface, the support roller 1′ is heated and the applicator roller 2′ is cooled; the strip to be coated is fed over the heated support roller 1′, then between the rollers 1′ and 2′ to apply the polymer layer, and finally over the cooled applicator roller 2′; pre-heating therefore occurs during the movement from the point E to the point C on the heated support roller 1′ and quenching therefore occurs during the movement from the point C to the point S on the cooled applicator roller 2′.

In the above method:

- the support roller 1′ is heated and held in contact with the internal face Bi of the strip only before application,
- the polymer composition is applied to the external face Be of the strip in the molten state using conventional application means, and
- the applicator roller 2′ is cooled and held in contact with the external face Be of the strip only after application.

In the above method, quenching begins immediately after application of the polymer layer; good adhesion of the metal strip is not obtained in this case because

cooling then occurs too quickly after application of the polymer layer.

For improved adhesion it is necessary to provide an intermediate coupling layer between the metal and the coating layer; this method proves to be very costly, however, since in reality the coatings are "two-layer" coatings, and generally necessitate two successive coating steps; despite the coupling layer, the adhesion on leaving the cold roller 2′ is often still insufficient and the coated metal strip must be heated to increase the adhesion of the coating, which represents an even greater penalty from the economic point of view.

SUMMARY OF THE INVENTION

An object of the invention is to provide a method of obtaining adherent and amorphous or weakly crystalline coatings in a single coating step; another object of the invention is to provide a method that is much more economical.

To this end, the invention provides a method of continuously coating a metal strip with a polymer composition, said strip having an "external" face to be coated and an opposite "internal" face, characterized in that it includes the steps of:

- feeding said strip continuously over a heated support roller with a non-deformable metal surface,
- applying said polymer composition to the external face of the strip using application means including said support roller, and
- heating said strip before, during and after application through contact of its internal face with said support roller.

The main advantages of the invention are as follows:

- the heating of the strip is more efficient, more homogeneous and better controlled because the heated support roller has a metal surface, which contributes to improving the adhesion of the coating, and
- the adhesion of the coating is significantly improved because the strip remains in contact with the

heated support roller after application of the polymer coating to provide "post-heating" of the strip.

Other advantageous features of the method of the invention are defined in the dependent claims.

According to an additional feature of the invention, the polymer composition is applied by rolling between an applicator roller which has a deformable surface and a strip bearing on said support roller; the surface of the applicator roller is more deformable than that of the support roller and can therefore advantageously espouse asperities and roughness of the surface of the strip to be coated.

The invention also provides a device for implementing the method of the invention of coating a metal strip having an external face to be coated and an opposite internal face, said device including:

- means for applying a layer of polymer composition to the external face of the strip, including a support roller provided with heating means, and
- means for feeding the strip continuously and defining a feed path of the strip in said device,

characterized in that:

- said support roller has a non-deformable metal surface, and
- said feed means feed the strip over said support roller with its internal face held in contact with the surface of said roller before, during and after application of said layer.

Other advantageous features of the device of the invention are defined in the dependent claims.

According to an additional feature of the invention, the device includes two successive coating stations, one for coating the external face, as previously described, and the other for coating the internal face.

The station for coating the internal face can have the same features as that for coating the external face.

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The invention will be better understood on reading

the following description, which is given by way of non-limiting example and with reference to the accompanying drawings, in which:

- Figures 1 to 4 shows prior art coating devices and methods: Figure 1 shows the general case of application to a strip moving over a support roller, Figures 2 to 4 show application to the strip by an applicator roller bearing on the support roller, and Figure 4 also shows fast cooling after application to obtain an amorphous or partly crystalline coating;

- Figures 5 to 11 show various embodiments of the invention that differ in the mode of application of the polymer and/or in the treatment of the strip after passing over the support roller and/or in whether a single-face or two-face application process is used; of Figures 5 to 11:

- Figures 5, 6, and 7 show application by extrusion in contact with the strip bearing on the support roller and Figures 8 to 11 show application by rolling a molten film or layer between the support roller and an applicator roller;

- Figures 5, 6, 8, and 9 show cooling of the strip on at least one cooling roller after application to the first face and Figure 11 shows cooling of the strip on at least one cooling roller after application to the second face;

- Figure 9 shows one particular method of cooling the surface of the applicator roller using a flexible metal skirt J which is itself cooled; and

- Figures 10 and 11 show a two-face application process.

Referring to Figure 5, the device for implementing the method of the invention of coating a metal strip B having an "external" face Be to be coated and an opposite "internal" face Bi includes:

- means for applying a polymer composition including:

- a support roller 1′ with a non-deformable metal surface and provided with heating means, and
- means 3 for applying a layer of the composition in the molten state to the external face Be of the strip; and

- means for feeding the strip continuously, including:
  - the support roller 1″, and
  - a cooling roller 4 provided with cooling means.

The means 3 apply a polymer layer in the molten state, are known in the art and are not described in detail herein, and include extrusion means and/or rolling means and/or polymer layer transfer means, for example.

To implement the method of the invention, the strip B is fed over the heated support roller 1″ and then over the cooled roller 4. While it is being fed over the roller 1″, a layer of polymer composition is applied to the strip at C by application means 3.

As it is fed, the strip comes into contact with the support roller 1″ along the line E and escapes from contact with the roller along the line P; the line P is on the circumference of the roller a considerable distance downstream of the line C in the rotation or feed direction.

During execution of the method the strip is therefore pre-heated on the roller 1″ between the lines E and C, then coated in the area C, then immediately "post-heated" on the same roller between the lines C and P, and finally cooled by passing it over the cooling roller 4 between the lines R and G.

In the configuration shown in Figure 5, the polymer layer applied to the face Be of the strip comes into direct contact with the surface of the roller 4; this can have drawbacks, for example the risk of damaging the coating of the strip.

Another configuration can be used to avoid this

drawback, such as that shown in Figure 6, in which the strip is fed differently over the cooling roller 4′ to prevent the coated face Be of the strip coming into direct contact with the roller.

In Figure 6, means 5 are provided for spraying the coated face Be of the strip between the support roller 1″ and the cooling roller 4′; these cooling means make the cooling more effective.

The pre-heating conditions are defined by the temperature of the roller 1″ and the feed distance between the lines E and C.

The post-heating conditions are defined by the temperature of the roller 1″ and the feed distance between the lines C and P.

The cooling conditions are defined by the temperature of the rollers 4 and 4′, the feed distance between the lines R and G and, where applicable, the additional cooling means such as the spraying means 5.

By means of the device and the method of the invention, a post-heating operation can be carried out very economically just after applying the polymer layer, by holding the coated strip in contact with the support roller 1″; this improves the adhesion of the layer to the strip.

Because the support roller 1″ has a metal surface, transfer of heat between the roller and the strip is very good, which improves control of the pre-heating and post-heating conditions.

In a variant of the invention, and depending on the nature of the polymer composition to be deposited and the speed at which the metal strip is fed, the strip has already undergone a first stage of pre-heating before it is fed over the support roller 1″; the device for executing the method of the invention then includes additional pre-heating means on the upstream side of the application means; conventional pre-heating means are used, for example induction heating means or infrared

radiant heating means.

In another variant of the invention, and depending on the nature of the polymer composition and the required microstructure of the intended coating, the coated metal strip is reheated after it has been fed over the support roller 1″; the device for executing the method of the invention then includes additional post-heating means downstream of the application means, for example replacing the cooling means 5 shown in Figure 6.

Conversely, when it is necessary to cool the coated strip by quenching it immediately after post-heating on the support roller, the cooling roller 4 is located as close as possible to the support roller 1″, to the point where the distance PR is zero or virtually zero (Figure 5 variant).

Referring to Figure 7, when a thermosetting polymer composition is used, the roller 4 is advantageously replaced by a heating device 6 for curing the polymer.

If a thermoplastics polymer composition is used and a coating that has a strongly amorphous structure is required, the main cooling means such as the rollers 4 or 4′ or the additional cooling means such as the spraying means 5 are adapted in a manner that is known in the art to obtain fast quenching to form a coating having a strongly amorphous structure.

By means of the invention, there is then obtained, in a highly economical manner, a coating which is both strongly amorphous, because of the quenching, and strongly adherent, because of the post-heating, and this is achieved under conditions that are easy to control.

In the case where the polymer composition layer is applied between two rollers between which the strip is fed, and in particular when the layer is applied by rolling (polymer film or layer) or by transfer (polymer layer), an applicator roller with a deformable surface and bearing on the support roller is used in addition to the support roller with its non-deformable metal surface.

In accordance with the invention, because the support roller has a non-deformable surface, it is possible to use an applicator roller with a deformable surface; using an applicator roller with a deformable surface enables the polymer coating to be applied to the metal strip in a highly homogeneous manner, ensures a highly homogeneous contact between the coating and the strip at all points of the strip, regardless of asperities and roughness, and prevents air bubbles from being trapped between the strip and the coating.

The expression "deformable surface" means a surface that can deform so as to espouse the roughness of the strip when the applicator roller is bearing on the support roller; examples of rollers with a deformable surface include rollers with a deformable rubber surface.

Thus whether the rolling process or the transfer process is used, important differences compared to the prior art are that the applicator roller has a deformable surface and that, after application of the polymer to the strip, the strip is not held with its coated external face in contact with the roller, but is instead held with its internal face in contact with the support roller; this feature of the movement of the strip after application of the polymer limits the risk of the coating sticking to the applicator roller; to limit further the risk of sticking, it is necessary to cool the surface of the applicator roller appropriately.

Figures 8 to 11 show variants of the method and the device for application between rollers.

Figure 8 is similar to Figure 5, except that the polymer composition P is applied by rolling a molten polymer film or layer between the applicator roller 2″ and the support roller 1″.

As previously indicated, the device preferably includes means for cooling the applicator roller to limit the risk of the polymer composition sticking to the applicator roller 2″.

Because the surface of the applicator roller is required to be deformable, the surface of the roller is generally made from a material that is a poor conductor of heat, and it is advantageous to cool the surface of the roller directly: Figure 9 shows one means of directly cooling the surface of the roller.

Figure 9 is similar to Figure 8 except that a flexible metal cooling skirt J is also fed around the applicator roller 2″. The skirt J is cooled by contact with a skirt-cooling roller 7.

The advantage of this variant is that the surface of the applicator roller 2″ is cooled very effectively.

It is nevertheless necessary to limit the cooling of the applicator roller 2″, to retain sufficient elasticity of its deformable surface.

Figure 10 shows a device of the invention for two-layer coating; a first layer of polymer P is applied to the first face of the strip B in exactly the same way as in Figure 8, with a cooling roller 4 very close to the support roller 1″ so that the coating is quenched immediately; after quenching, the strip coated on one face is then diverted by a deflector roller 10 to offer up its other face for coating with a polymer P″ between two rollers 1 and 2, in a manner similar to that shown in Figure 2; the surface and the temperature of the roller 1 are matched to the polymer P″ that comes into contact with the roller; the roller 2 has a deformable surface; on escaping from the grip of the rollers 1 and 2, the strip coated on both faces is then fed into conventional post-heating means 8, after which it is quenched in the conventional way; the conditions of post-heating in the means 8 and the conditions of quenching are chosen to obtain the required coating structure.

The device shown in Figure 10 therefore includes:

- a first station for coating between the rollers 1″ and 2″, in which the roller 1″ provides pre-heating and post-heating of the strip, and

- a second station for coating between the rollers 1 and 2, in which the roller 1 does not apply post-heating of the strip, even though it has a hard surface and is used for pre-heating the strip, because the coated strip does not remain in contact with this roller beyond the line of application of the coating on escaping from the grip of the rollers 1 and 2.

The device shown in Figure 11 also includes two stations for coating between two rollers 1″, 1″′ and 2″, 2″′ to obtain a strip coated with polymer on each face; at each station, the support roller 1″, 1″′ has a hard metal surface and the strip is laced around the roller both before and after the line of application of the polymer P, P″ that corresponds to the line of grip between the rollers; in each station, the applicator roller 2″, 2″′ has a deformable surface; to prevent the risk of the polymer P sticking to the support roller 1″′ in the second station, the support roller 1″′ is coated with a thin non-stick layer 9, for example a layer based on PTFE.

The non-stick layer can be of metal, for example with an amorphous or quasi-crystalline structure of the type obtained by hyper-quenching.

Unlike the Figure 10 situation, after the first coating station, the strip coated on one face is fed directly to the second station to coat the other face: there is no cooling roller and no deflector roller between the two stations.

The coating previously applied to the first face of the strip remains in contact with the roller 1″′ with its non-stick layer 9 before, during and after application of the polymer P″ to the second face; as previously, the nature of the surface and the temperature of the support roller 1″ are chosen accordingly; the contact of the strip with the roller 1″′ after application can be extended over one-quarter of the circumference of the roller, as shown, or even as far as one-half of the

circumference, so as to prolong the transfer of heat to provide the required post-heating.

If the transfer of heat is slowed by an organic non-stick layer 9 and/or by the first coating, a roller 1‴ of larger diameter can be used to increase the time of contact between the strip and the roller and prolong the transfer of heat.

Both faces of the coated strip are then quenched by passing the strip over two successive cooling rollers 4, 4″ which are disposed so that the two coated faces come alternately into direct contact with the two rollers in succession; quenching begins as soon as the strip loses contact with the support roller 1‴ of the second station.

Other conventional quenching methods can be substituted for quenching by rollers, such as water quenching.

Without departing from the scope of the invention, all variants and improvements previously described in the case of a single-face coating process can be applied at the second station.

A strip coated with polymer on both faces is then obtained.

The device and the method of the invention have been used with advantageous to prepare steel strips coated with polyethylene or polypropylene films for use in the fabrication of packaging.

The coatings have the following advantages: absence of solvent during fabrication steps, good surface appearance and good capacity for printing the coated faces of the plate, and improved organoleptic qualities.

Using the method of the invention, it is possible to obtain coatings that are very adherent to the plate in a dry or moist atmosphere, even after sterilization, and sufficiently amorphous to be readily deformable, in particular for there to be no risk of porosity appearing after pressing.